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Changes in Color and Physiological Components of The Postharvest Mango (*Mangifera indica* L.) Influenced by Different Levels of GA3

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Abstract - This experiment consisted of two popular mango varieties in Bangladesh (viz., Langra and Khirshapat) and four different levels of Gibberellic acid (GA3) solution, namely control, 100, 200 and 400 ppm. The two factors experiment was assigned in randomized complete block design with tree replicates. Data obtained from various biochemical analyses in terms of physicochemical properties and shelf life of postharvest mango, were recorded and statistically analyzed for comparison among the mean values using DMRT and LSD. The results of the experiments exhibited that only the single effect of varieties was found to be significant in most of the parameters studied. Variety the Langra performed better in accumulating higher quantity of dry matter, ash, vitamin c content in all four experiments over Khirshapat. On the other hand, the Khirshapat showed better performance in achieving higher quantity of moisture, progressively lost physiological weight as well as extended shelf life and delayed skin color changes than Langra at all the storage duration.

Keywords: Postharvest mango; Gibberellic acid; physiological components.

Introduction

Mango (*Mangifera indica* L.) is classified as a climacteric fruit (Wang and Shiesh, 1990) and harvested before the onset of the climacteric (Mitra and Baldwin, 1997). However, when physiologically mature at 105-112 days after fruit set, to get optimum fruit quality, whereas immature fruit do not ripen normally (Jha *et al.,* 2006; Mitra and Baldwin, 1997). Due to the differences among mango types, varieties, production conditions and locations, chemical and physiological variables have been examined to define the optimal stage of maturity for harvest (Mitra and Baldwin, 1997). Malnutrition and under nutrition have now become an alarming problem of the people of the third world countries affecting their economic and physical development. Protein–energy malnutrition, vitamin and mineral deficiencies are the most serious nutritional disorder in low income groups.

Postharvest losses and deterioration of nutritional quality of fresh fruit are the most important problems in tropical and sub- tropical regions of the world. A huge quantity of nutritious fruits is being markedly deteriorated due to the lack of proper knowledge on post harvest management practices. As a result, people do not have sufficient nutrition from fruits according to their requirements. A considerable amount of fresh fruits goes waste every year through post-harvest decay. It is the most important fruit of Asia and ranks fifth world-wide in production after bananas, citrus, grapes and apples. Mango is rich source of vitamins A, C and D. Due to its excellent taste, flavour and juice, it is rightly called the king of fruits. Application of different postharvest treatments viz., paraffin coating, perforated polyethylene cover, unperforated polyethylene cover, hot water treatment and low temperature in refrigerator are very much important obstacles to normal respiration of mango fruits. These treatments strongly impede in ethylene synthesis that resulted in low respiration and delay ripening. These materials also reduced the losses and prolonging the shelf life of mango (Tefera *et al.,* 2007; Benitez *et al.,* 2006; Fawaz, 2006; Muy *et al.,* 2004; Fonseca *et al.,* 2004). Gibberellic acid (GA3) 2000 ppm gave a highly effective treatment for retarding rate (Parmar *et al.,* 1989). If mangoes are treated with GA3 150 ppm and Bavistin 1000 ppm, both the treatment slowdown the process of ripening. Significant delay in the ripening of mango fruits was observed with Gibberellic acid (Khader, 1992). The interaction between post-harvest treatments and storage periods was found to be significant for physical quality parameters and non-significant for chemical quality parameters, whereas storage period significantly affected both type of parameters (Singh *et al.*, 2012). These treatments performed effectively in reduction of postharvest decay, and extension of shelf life of mango (Ranjan *et al.,* 2005; Dhemre and Waskar, 2004; Gautam *et al.,* 2003; Reddy and Haripriya, 2002; Ahmed and Singh, 2000). Apparently, these treatments deteriorate the qualities of fruits to some extent, but the reduction of losses and extension of postharvest life of mango will help to increase the market price in the off seasons which play a good role in the economic development.

In the present study it was aimed to investigate the behavioral pattern of physicochemical properties of postharvest mango in the storage conditions. To select the best method for reduction of losses and extension of postharvest life of mango and to assess the shelf life of selected fruits as influenced hormonal treatments under different storage conditions.

Materials and Methods

Experimental materials

Two mango varieties namely, the Langra and the Khirshapath were selected as experimental materials. The mango varieties undertaken for investigation were collected from mango growing areas of Kansart, Shibgonj Upazila of ChapaiNowabgonj district and Chirghat upazila of Rajshahi district, Bangladesh. Material used as postharvest treatments (viz., GA3) was collected as analytical grade. The experiment consisted of two factors and assigned in Randomized Complete Block Design (RCBD) with three replicates. The Langra (V_1) and the Khirshapat (V_2) were treated with different levels of gibberellic acid, namely control (G_0), 100 ppm (G_1), 200 ppm (G_2) and 400ppm (G_3). Each block contained 8 treatments.

Preparation of GA solution

The solution of GA3 of 100, 200, and 400 ppm was prepared by dissolving 100, 200, and 400 mg of GA3 in one litre of distilled water. The fruits of both varieties were dipped into the solution for a period of 5 minutes. Care was taken to ensure sufficient absorption of GA3 by the fruits and then they were stored at room temperature on brown paper.

Physiological weight loss of mango fruit

A specific fruit from each treatment combination of each block was taken and individually weighed using electrical balance and sometimes rough balance and then kept for ripening. The process was continued still ripening at three days interval. Percent total weight loss was calculated by using the following formula:

% Weight loss (WL) = IW-FW/IW x 100

Where, % WL = Physiological weight loss, IW = Initial fruit weight and FW = Final fruit weight

Percent dry matter content of pulp

Percent dry matter content was calculated by using the data obtained during moisture estimation using the following formula: %Dry matter = 100 - % moisture content

Percent ash content of pulp

The oven-dried sample from 5.2.4 above was ashed in a muffle furnace at 600^0 C for six hours after initial pre-ashing at 200^0 C and percent ash was calculated as follows

% Ash = $\frac{A}{I} \times 100$, Where, A= Weight of ash and I = Initial weight of pulp

Percent moisture content of pulp

Ten g of fruit pulp from each treatment combination of each replication was taken in a porcelain crucible (which was previously cleaned, heated at 100^0 C, cooled and weighed). The crucible was then placed in an electrical oven at 80^0 C for 72 hours until the weight became constant. It was then cooled in a desiccator and weighed again.

Calculation % Moisture = IW-FW/IW x 100, Where, IW = Initial weight of pulp, FW = Final weight of oven dried pulp

Estimation of vitamin C content of mango pulp

Vitamin C of mango pulp was estimated by the titrimetric method as stated by Bessey and King (1933). Reagents: The following reagents were used for estimation of vitamin C i) 3% Metaphosphoric acid (HPO_3), 3g of metaphosphoric acid was dissolved in 80 ml of acetic acid and made volume up to 100 ml with distilled water. ii) Standard vitamin C solution (0.1 mg/ml), 10mg of pure vitamin C was dissolved in 3% metaphosphoric acid and made volume up to 100 ml with this acid.

Results and Discussion

Changes in skin color

Different doses of Gibberellic acid (GA3) strongly influenced the skin color of both the fruits, namely Langra and Khirshapat (Table 1). Both varieties demonstrated the original green color at the initial day of harvesting. At 3rd day, the Langra developed into a trace in yellow color at control (G_0) and light green color at 100 ppm (G_1) and 200 ppm (G_2) as well as held green color at 400 ppm (G_3) treatment. The Khirshapat showed trace in yellow color at control, light green color at G_1 and G_2 treatment. But, it retained its original green color at G_3 treatment. At 6th day, the Langra was noticed yellow at control (G_0), yellowish green at 100 ppm (G_1) and 200 ppm (G_2) while light green was observed from 400 ppm (G_3) treatment. On the other hand, the Khirshapat developed yellowish green, trace in yellow and yellowish green color at G_0, G_1, and G_2 treatments, respectively but, it retained its original green color at G_3 treatment.

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Table 1. Changes in skin color of two mango varieties as influenced by different doses of Gibberellic acid during storage at ambient condition

		Days after storage					
Varieties	Treatments	Initial	3	6	9	12	15
V_1	G_0	Green	Trace in yellow	Yellow	Deep yellow	Blackish yellow	_
	G_1	Green	Light green	Yellowish green	Greenish yellow	Yellow	_
	G_2	Green	Light green	Yellowish green	Greenish yellow	Yellowish green	Yellow
	G_3	Green	Green	Light green	Trace in yellow	Yellowish green	Greenish yellow
V_2	G_0	Green	Trace in yellow	Yellowish green	Yellow	Light spotted yellow	_
	G_1	Green	Light green	Trace in yellow	Greenish yellow	Yellow	_
	G_2	Green	Light green	Yellowish green	Trace in yellow	Yellowish green	Yellow
	G_3	Green	Green	Green	Green	Trace in yellow	Yellowish green

Table indicates: V_1 = Langra, V_2 = Khirshapat, G_0 =Control, G_1=100 ppm of GA3, G_2=200 ppm of GA3, G_3 =400 ppm of GA3.

At 9th day, the Langra gave deep yellow color at control, greenish yellow at G_1 and G_2 as well as trace in yellow color at G_3 treatments. Khirshapat showed yellow color at control, greenish yellow and trace in yellow at G_1 and G_2 treatments. But, it also retained its original green color at G_3 treatment. After 12th day of storage, the Langra was found blackish yellow at control and yellow at G_1 and yellowish green at G_2 and G_3 treatments. On the other hand, Khirshapat was also found blackish yellow color at G_0, yellow, yellowish green and trace in yellow at G_1, G_2 and G_3 treatments, respectively. After 15 days of storage, Langra showed no existence at control and G_1 treatment yellow and greenish yellow at G_2 and G_3 treatments, respectively. The Khirshapat completely denoted as putrefied condition at G_0, and G_1, treatment and yellow and yellowish green was noticed from G_2 and G_3 treatments, respectively.

Physiological weight loss

Varieties had highly significant variation in relation to PWL at different days after storage (Table 2). At each day, the Khirshapat (V_2) gradually showed more PWL as compared to the Langra with the increase of storage duration (Table 2). The highest (10.62%) and lowest (9.72%) of PWL were recorded from the Khirshapat and the Langra at 12th day, respectively. The results explored that total PWL progressively augmented with the advancement of storage duration. The findings also elucidated that the Langra showed better performance in respect of PWL as compared to the Khirshapat. Water loss through lenticels seems to be the probable cause of physiological weight loss in the fruits during storage. Lower lenticel density in the Langra facilitated lesser water loss leading to minimum total weight loss (Azad, 2001). Singh *et al.* (2000) also reported more or less the same findings.

Table 2. Changes of physiological weight loss and moisture content in mango varieties during storage at ambient condition. In a column values having the same letter(s) do not differ significantly as per DMRT at 5% level; * indicates at 5% level; ** indicate at 1 % level; *** indicate at 0.1% level; NS means non –significant.

Treatments	Physiological weight loss (%) at different days				Moisture content (%) at different days				
Variety (V)	3	6	9	12	Initial	3	6	9	12
V_1	5.15 b	6.65 b	8.13 b	9.72 b	82.43 b	83.53 b	84.53 b	85.36 b	85.80 b
V_2	6.05 a	7.78 a	9.02 a	10.62 a	84.36 a	85.62 a	86.68 a	87.40 a	87.85 a
Level of significance	***	***	***	***	***	***	***	***	***

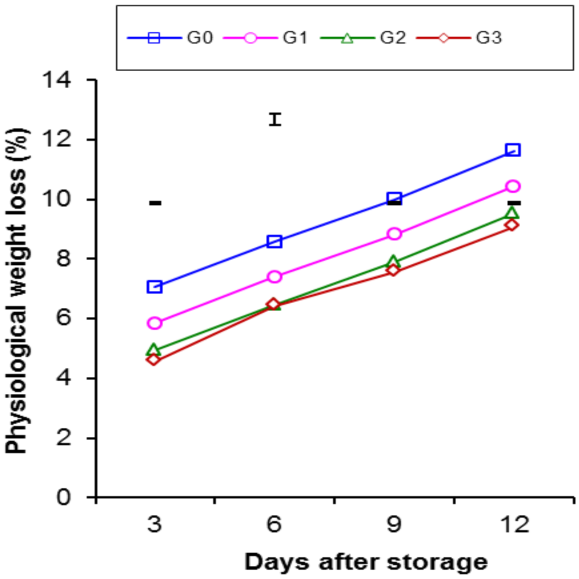

Figure 1. Effect of different doses of Giberellic acid (GA 3) on physiological weight of mango at different days after storage. Vertical bars represent LSD at 0.05 level

Analysis of variance of mango in terms of PWL as influenced by different doses of Gibberellic acid (GA3) showed highly significant variation at different days after storage (Figure 1). At different days, it explored that control treatment was very faster in PWL compared to G_1, G_2 and G_3 treatments. At 12th day, the maximum PWL (11.64%) was noticed at G_0 and minimum (9.09%) at G_3 treatment (Figure 1). These phenomena happened might be possibly due to 400 ppm of GA3 solution reduced the metabolic activities of mango resulting in lower PWL. These results are in partial coincided with the findings of Reddy and Haripriya (2002). The combined effect of varieties and different doses of GA3 solution demonstrated significant variation in PWL at different days after storage. At different days, it denoted that various treatments combination affected in PWL gradually with the advancement of storage duration. At 12th day, there showed the maximum PWL (11.97%) at V_2G_0 and the minimum (8.65%) at V_1G_3. It also indicated that the langra lost the minimum amount of water along with G_3 treatment followed by the other treatment combinations.

Moisture content

The analysis of variance of imposed varieties exhibited highly significant variation in moisture content at different days after storage except initial day (Table 2). At different days, it interpreted that moisture content augmented with the passing of storage duration. The increasing trend was more or less the similar from initial to 9th day and thereafter, it reduced the increasing trend due to decay. It also illustrated that each day of storage, the Khirshapat gave more moisture comparing to the Langra. The highest (87.85%) and the lowest (85.85%) were recorded from V_2 and V_1 at 12th day, respectively (Table 3). These results are in agreement with the findings of Azad (2001). This variation might be possible due to genetical, location, weather effect and soil quality or maturity of the fruit.

Variation among the means of different doses of GA3 solution in relation to moisture content was noticed to be significant at different days after storage except initial day (Figure 2). At different days of storage, moisture content increased in a continuous stream with the increase of storage duration. The last increased point was observed from control and G_1 treatment at 6 and 9th day (Figure 2) whereas; G_2 and G_3 treatments produced increasingly onward. Untreated fruit gave the highest moisture content (87.40%) at 9th day and the lowest (85.30%) was recorded from G_3 treatment. The increasing trend of moisture content from initial to 6th day might be possibly due to metabolic activities and osmotic pressure inside the mango fruit as well as its decreased might be due to suppression of metabolic activities resulting in decaying and drying.

The combined effect of varieties and different doses of GA3 solution in respect of moisture content showed non significant variation at different days after storage. At different days of storage, moisture content was added in mango with the increase of storage period. The treatment combinations of V_2G_0, V_2G_1 and V_2G_2 provided the maximum moisture content (88.40%, 88.40% and 88.80%) at 6, 9 and 12th days, respectively (Table 3.3). In this storage period, the lowest values (83.50%, 84.30% and 85.10%) were added from the treatment combination of V_1G_3. The increase of moisture content from initial to consequent day might be possible due to metabolic activities and osmotic principles and decreasing in a certain day might be due to suppression metabolic activities resulting in drying, transpiration and evaporation.

Dry matter content

The variation in varieties means in relation to dry matter content showed highly significant at different days after storage (Table 3). At each day, dry matter decreased successively with the passing of storage duration. It indicated that the Langra provided comparatively more dry matter comparing to Khirshapat. At initial day, the Langra produced higher (17.65%) amount of dry matter whereas the Khirshapat gave lower (15.64%) and at 12th day, the Langra received the maximum (14.20%) whereas Khirshapat received 12.15 % (Table 3). These results are in partially supported by the findings of Hassain (1991).

Different doses of GA3 solution imposed in this study in terms of dry matter content of mango pulp showed highly significant variation at different days after storage (Figure 3). At different days of storage, dry matter content reduced continuously with the advancement of storage duration (Figire 3). It also denoted that G_3 treatment contributed the highest dry matter (15.50%) at 6th day whereas; the lowest dry matter (12.65%) was reported from control.

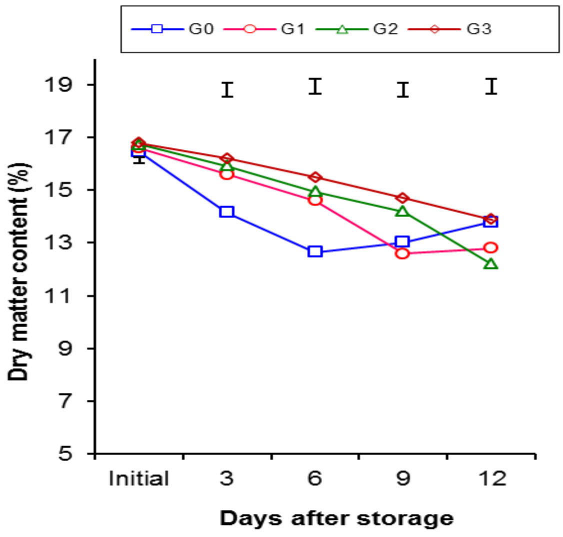

Figure 3. Dry matter content of mango pulp as influenced by different doses of Gibberellic acid (GA 3) at different days after storage. Vertical bars represent LSD at 0.05 level

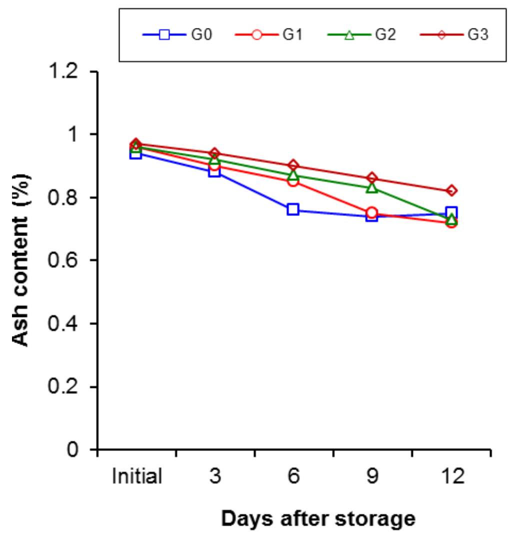

Figure 4. Ash content of mango pulp as influenced by different doses of Gibberellic acid (GA 3) at different days after storage. Vertical bars represent LSD at 0.05 level

The combined effect of varieties and different doses of GA3 solution on dry matter content of mango pulp exhibited non significant variation at different days after storage. At initial day, the highest dry matter content (17.80%) was obtained from the treatment combination of V_1G_3 which was statistically similar with the treatment combination of V_1G_0, V_1G_1 and V_1G_2 whereas; the lowest (15.40%) was obtained from the treatment combination of V_2G_0 which was also statistical similar with the combinations of V_2G_1 and V_2G_2. At 12th day, the highest value (14.90%) was noticed from the treatment combination of V_1G_3 and V_1G_0 and the lowest value (11.20%) was noticed from V_2G_2. The successively decrease in dry matter content with the advancement of storage period might be possibly due to breaking down the complex carbohydrates into simple molecules and H_2O as well as adding water through osmotic process and metabolic activities. The decreasing of dry matter content of mango pulp was not supported by the findings of Hossain (1999).

Ash content

Variation in varieties means in respect of ash content of mango pulp exhibited significant variation at different days after storage except 3rd day (Table 3). At different days of storage, values of ash content decreased continuously with the passing of storage duration. It was noticed that the langra produced comparatively more ash than the Khirshapat at all days of storage. Higher (1.01%) ash content was recorded from the Langra at initial day whereas the Khirshapat gave (0.90%) and again, higher (0.81%) was gathered from the Langra and lesser achievement (0.70%) was gathered from the Khirshapat. Different doses of GA3 solution were identified as non significant variation in respect of ash content of mango pulp at different days after storage. It indicated that ash content influenced by different doses of GA3 decreased slightly from G_3 treatment and markedly from control (Figure 4).

Table 3. Dry matter and ash content of mango pulp changes in varieties during storage at ambient condition

Treatments	Dry matter content (%) at different days					Ash content (%) at different days				
Variety (V)	Initial	3	6	9	12	Initial	3	6	9	12
V_1	17.65 a	16.48 a	15.48 a	14.65 a	14.20 a	1.01 a	0.96	0.90 a	0.85 a	0.81 a
V_2	15.64 b	14.46 b	13.38 b	12.61 b	12.15 b	0.90 b	0.86	0.79 b	0.74 b	0.70 b
Level of significance	***	***	***	***	***	*	NS	*	*	*

The combined effect of varieties and different doses of GA3 solution were recorded to be non-significant variation in terms of ash content of mango at various days after storage. There was no available research finding regarding ash content of mango. It also exposited that ash content was intimately associated with dry matter content. The results of the present study elucidated that ash content decreased in relation to dry matter content.

Vitamin C content

Differences between two varieties in relation to vitamin C content of mango pulp were highly significant at different days after storage. At various days of storage, it expounded that Langra showed better performance in synthesis of vitamin C as compared to Khirshapat (Table 4). It also narrated that quantity of vitamin C diminished with the advancement of storage period. At the initial day, the Langra accumulated the highest (131.65 mg/100 g) quantity of vitamin C whereas; the Khirshapat gave the lowest (45.99 mg/100 g). At 12th day, the Langra again, was notified the

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highest (17.18 mg/100 g) producer of vitamin C and the Khirshapat was the lowest (9.25 mg/100 g) producer (Table 4). These results annotated that vitamin C content successively came down with the augmentation of storage duration in both the varieties. It might be probably due to rising of ethylene synthesis resulting in oxidation of ascorbic acid. The results of the present study are in agreement with the findings of Azad (2001) and Absar *et al.* (1993).

Table 4. Changes of vitamin C content of mango pulp in varieties during storage at ambient condition

Treatments	Vitamin C content (mg/100 g) at different days				
Variety (V)	Initial	3	6	9	12
V_1	131.65 a	111.48 a	64.40 a	35.23 a	17.18 a
V_2	45.99 b	34.38 b	19.49 b	11.90 b	9.25 b
Level of significance	***	***	***	***	***

Variation among the means of different doses of GA3 solution in terms of vitamin C content exhibited highly statistical significant at different days after storage. At initial day, green mangoes treated with GA3 dose accumulated the highest (89.43 mg/100 g) amount of vitamin C whereas; the lowest (87.78mg/100 g) was accumulated in the untreated mango but, the lowest value was statistically at par with G_1 treatment. After initial level, it diminished in a continuous stream with the passing of storage time (Figure 5). It also explored that diminishing rate was faster in control, but it was slower in G_3 treated fruit. At 12th day, vitamin C content ranged between 8.70 to 17.70 mg per 100 g of pulp obtained from control (T_0) and G_3 treated fruit, respectively. The reduction of vitamin C content in both treated and untreated mangoes at different storage period might be possible due to oxidation of ascorbic acid and GA3 dose was possibly causing delay ripening which resulted in lower oxidation of vitamin C. These results are in supported by the findings of Hossain (1999). Jain and Mukherjee (2001) also reported the similar results.

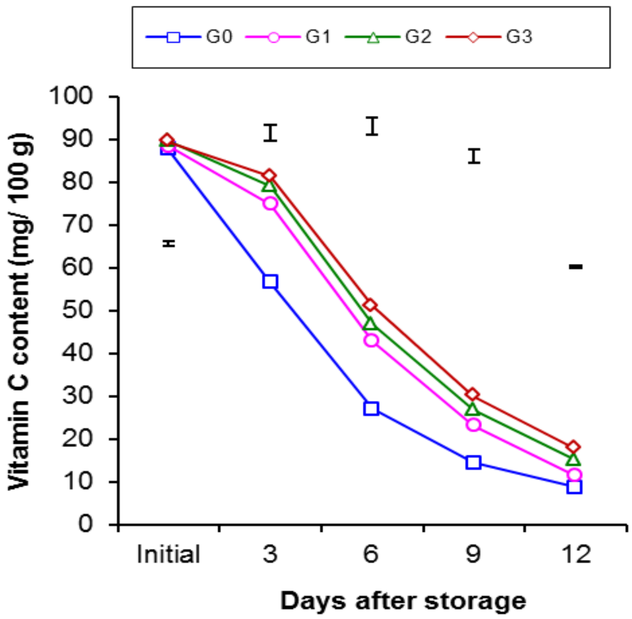

Figure. 5 Effect of different doses of GA3 on vitamin C content of mango pulp at different days

The combined effect of varieties and different doses of GA3 solution showed significant variation in respect of vitamin C content at different days after storage except initial day. At various days during storage, it was notified that vitamin C content fell away with the rising of storage period. The quantity of vitamin C ranged between 4.90 to 21.50 mg per 100 g of fresh mango pulp at 12th day in the treatment combination of V_1G_3 and V_2G_0, respectively.

Conclusions

The increase of moisture content from initial to consequent day might be possible due to metabolic activities and osmotic principles and decreasing in a certain day might be due to suppression metabolic activities resulting in drying, transpiration and evaporation. The successively decrease in dry matter content with the advancement of storage period might be possibly due to breaking down the complex carbohydrates into simple molecules and H_2O as well as adding water through osmotic process and metabolic activities. The combined effect of varieties and different doses of GA3 solution were recorded to be non-significant variation in terms of ash content of mango at various days after storage. The reduction of vitamin C content in both treated and untreated mangoes at different storage period might be possible due to oxidation of ascorbic acid and GA3 dose was possibly causing delay ripening which resulted in lower oxidation of vitamin C. In future it is important to elucidate the reaction mechanism of using different growth regulators in fruits, which is also our consideration.

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